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Report of the PSARC Groundfish Subcommittee Meeting, November 21-24, 2000

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 2000-07
DECEMBER 2000

GROUNDFISH

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SUMMARY

Working Paper G2000-01: Lingcod stock assessment and recommended yield options for 2001
The status of lingcod fisheries on the B.C. coast was assessed using catch histories and trawl catch per unit effort (CPUE).

The Subcommittee agreed with the authors that the available information provided no basis for changing any of the previous harvest recommendations.

The Subcommittee recommended that the available length, age and CPUE data be used in a population dynamics model for the next assessment. This approach might be helpful for Areas 3CD and 5AB.

The Subcommittee recommended that the issue of winter closures of lingcod fisheries be examined both with respect to estimating the sex proportions in the fishery and examining the impact of this fishing on lingcod stock dynamics.

Working Paper G2000-02: Sablefish stock assessment for 2000 and recommended yield options for 2001
A new assessment was presented based mainly on tag return data. Attention was drawn to the stock structure issue.

The Subcommittee endorsed the 2000/2001 yield recommendations.

Given the possibility for a distinct Southern B.C. stock and a single Northern B.C./Alaska stock, stock structure should be reviewed to determine practical management units.

Working Paper G2000-03: Silvergray rockfish (*Sebastes brevispinis*) assessment for 2000 and recommended yield options for 2001/2002
An assessment of this species was presented including a catch age analysis. New yield options were proposed which included an update of reference fishing mortality.

The Subcommittee recommended that attempts to increase the amount of age sampling should be made to address limited age data.

Working Paper G2000-04: Stock assessment of rock sole and English sole in Hecate Strait for 2000/2001
The assessment was based on a catch age analysis calibrated with the Hecate Strait groundfish assemblage survey results. New reference fishing mortalities were presented.

The Subcommittee recommended that the reference points should include F=M and F=0.75M yield options, and the historical $F_{0.1}$ yield options.

The Subcommittee supported the authors recommendations that assessments should be conducted on these stocks in 2001.

Working Paper G2000-05: Estimating stock biomass from tow-by-tow data for Pacific groundfish
A methodology was described for using on-board observer fishery data to calculate stock biomass indices that include consideration of both fish density (CPUE) and area fished.

The Subcommittee endorsed the approach as a means of investigating patterns in commercial and survey indices.

Working Paper G2000-06: Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis*) for 2000
An assessment of this new fishery was presented which included analysis of CPUE data and a length-based analytical model.

The Subcommittee endorsed the recommendations in the working paper provided that monitoring of longspine thornyhead stocks continue.

Working Paper G2000-07: Design of a bottom trawl survey for three slope groundfish species in Canadian waters
Elements important for the design of a bottom trawl survey for 3 slope rockfish species were presented.

The Subcommittee continues to support the development of a survey directed at slope rockfish. However, the Subcommittee did not endorse the recommendation to proceed with slope rockfish surveys pending the development of a specific survey objectives and design.

The Subcommittee recommended the development of a joint DFO/industry working group to develop survey objectives, design, and analysis.

Working Paper G2000-08: Assessment of Pacific cod in Hecate Strait, Nov. 2000
An assessment using a non-equilibrium surplus production model was presented.

The Subcommittee noted that harvest reductions are necessary to maintain current biomass and further reductions would be required to achieve rebuilding.

The Subcommittee recommended that improvements to the stock assessment model, incorporating more of the stock dynamics of Pacific cod, need to be done for the 2001 assessment.

Yield options derived from the November 2000 groundfish assessments are given in Table 1. The terms "high and low risk" have been removed from the yield options table because there is no quantitative basis for them.

Table 1: Summary of yield advice based on advice presented at this meeting.

AREA	SPECIES	2000 YIELD OPTIONS	2001 YIELD OPTIONS
4B	Lingcod	0	0
3C	Lingcod	<1000	<1000
3D	Lingcod	400-800	400-800
5AB	Lingcod	1100-2200	1100-2200
5CDE	Lingcod	1000	1000
Coastwide	Sablefish	2977-5052	3700-4500
3CD	Silvergray rockfish	150-425	F = .5M 152 F = .75M 228 F = M 296
5AB	Silvergray rockfish	350-700	F = .5M 214 F = .75M 319 F = M 422
5CD	Silvergray rockfish	125-400	F = .5M 96 F = .75M 217 F = M 288
5E	Silvergray rockfish	175-300	F = .5M 137 F = .75M 204 F = M 270
5CD	Rocksole	800-1100	F = .75M 517 F = M 673 F = $F_{0.1}$ 733
5CD	English sole	500-600	F = .75M 343 F = M 446 F = $F_{0.1}$ 544
Coastwide	Longspine Thornyhead	245-425	see text
5CD	Pacific cod	600-1500	see text

INTRODUCTION

The Pacific Scientific Advice Review Committee (PSARC) Groundfish Subcommittee met November 21-24, 2000 at the Pacific Biological Station in Nanaimo. The meeting agenda (Appendix 1) was developed at planning

meetings held in July and September. A list of meeting participants is included as Appendix 2. The Subcommittee reviewed eight working papers. Working Paper titles, authors and reviewers are listed in Appendix 3.

GENERAL SUBCOMMITTEE DISCUSSION

Assessment Planning and Preparation

The main objective of the groundfish assessment meetings is to provide scientific review for advice on stock management. However, it is inevitable that new assessment techniques are developed for specific stocks, interesting issues are identified which deserve additional research, and there may be important assessments that need to be undertaken for the next round of advice. Time is always a limiting factor for the meeting. It was generally accepted that planning for each meeting should begin shortly after the end of the current meeting. Three milestones were identified assuming that the assessment meeting will be held in November.

1) There should be an assessment planning meeting held in the early spring with managers, industry, first nations, and other stakeholders to identify stocks for which assessments will be produced.

2) There should be a technical meeting in early September at which new methods and approaches can be reviewed so that more time is available at the assessment meeting for reviewing results.

3) There should be a meeting, or series of meetings, with stakeholders to go over issues and data to ensure the analysts are aware of the most pertinent events in recent fisheries.

It was also suggested that the assessment meeting could be more effectively structured as a workshop where time is allotted for analysts to discuss methods and experiment with alternative model formulations. The agenda could include both plenary and working sessions. Additional days may be needed if such an approach is taken. This option should be considered when planning the next PSARC meeting.

Conservation Objectives

A common theme in the assessments and reviews presented at this meeting was the lack of clearly defined conservation objectives and biological reference points for providing advice. While most authors suggested fishing mortality reference points, these were drawn from available literature rather than reflecting a common objective. There were fewer suggested reference points for stock size limits and/or targets. Most national and international fisheries management agencies have clearly defined conservation objectives and there is a large

collective experience to draw from. It is generally recognized that conservation objectives are biologically based and may be determined in the absence of clearly defined social and economic objectives. Social and economic objectives are usually defined subject to achieving conservation objectives.

It is recommended that work be undertaken in the coming year to define a set of biological reference points for B.C. groundfish stocks that may be used to guide analysts in providing scientific advice for management. Since this work will be of specific relevance to PSARC deliberations, it should be reviewed through the PSARC Groundfish Subcommittee in advance of the next assessment meeting.

Submissions by External Participants

PSARC meetings have benefited from comments and input by invited External Participants for several years now. Most of this input occurs during discussions and as such, often may loose some impact because there is insufficient time to follow up on the observations or to undertake additional analyses to verify and better understand the implications of the observations. It was suggested that External Participants be encouraged to make written submissions on the status of fisheries being assessed in advance of the meetings so that analysts can investigate their implications. These observations should be accompanied by supporting documentation on what was observed, where, when, and by whom.

Trawl Observer Data

All authors made extensive use of the detailed catch, effort and biological sample data collected by observers in the groundfish trawl observer program. The Subcommittee noted that considerable progress has been made on making these valuable data available efficiently and congratulates all those involved in the recent improvements.

Historic Yield Table

Last year's Subcommittee Proceedings (CSAS Proceedings 99/32) presented a table of historic yield recommendations from previous Subcommittee meetings along with references to the original documentation. While preparing for this year's lingcod assessment, it was discovered that the source references provided last year were inaccurate. The correct references are provided in Appendix 4.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

G2000-01: Lingcod stock assessment and recommended yield options for 2001

J. King and M. Surry **Accepted subject to revisions**

Summary

Lingcod stocks were examined for the Strait of Georgia, southwest and northwest coasts of Vancouver Island, Queen Charlotte Sound, Hecate Strait and the west coast of the Queen Charlotte Islands. Interpretation of stock condition relies on recent trends in catch statistics and limited age composition data of the commercial trawl fishery.

In the Strait of Georgia (Area 4B), a catch per unit effort index based on creel survey data has increased in recent years, but not to levels that indicate an improvement in stock conditions. A continued strategy for rebuilding of lingcod stocks in Area 4B is recommended.

Off the southwest coast of Vancouver Island (Area 3C), a 25% Qualified catch per unit effort index (CPUE) based on qualified trawl catches in May-September did not provide evidence for recent changes in abundance. In addition, the age proportion data available for the trawl fishery did not indicate that either a strong cohort or a series of strong cohorts were entering the fishery. The authors have no new information to revise the existing yield recommendation that total removals do not exceed 1000 tonnes .

Off the northwest coast of Vancouver Island (Area 3D), a 25% Qualified CPUE based on qualified trawl catches in May-September did not provide evidence for recent changes in abundance. There are no age proportion data to provide information on cohort strength in the fishery. The authors have no new information to revise the existing yield recommendation of 400-800 tonnes.

In Queen Charlotte Sound (Areas 5A/B), a 25% Qualified CPUE based on qualified trawl catches in May-September did not provide evidence for recent changes in abundance. Age proportion data available for the trawl fishery did not indicate that either a strong cohort or a series of strong cohorts were entering the fishery. The authors have no new information to revise the existing yield recommendation of 1100-2200 tonnes. However, it should be noted that this yield range was based on a model that used inaccurate age data and therefore growth and mortality estimates were not well determined.

For the areas in Hecate Strait (Areas 5C/D) and west coast of the Queen Charlotte Islands (Area 5E), there is no new information to revise the existing

yield level of 1000 tonnes for all three areas combined.

Reviewers' Comments

Both reviewers commended the authors for summarizing the historical information on the lingcod fishery. Specific comments are summarized below.

Since the harvest advice is partially conditioned by CPUE trends, reviewer #1 suggested that the next stock assessment review the strengths and weaknesses of these data . The authors might consider a stock production analysis. Similarly, both reviewers suggested that while biological sampling and ageing data for lingcod are limited, it appeared that sufficient data exists for areas 3C and 5AB to attempt some form of catch-age analysis and stock reconstruction. They recommended that the applicability of such an analytical tool for lingcod assessments be investigated for the next assessment.

Both reviewers agreed with the authors that it is important to recognize and incorporate current understanding of climatic impacts on marine ecosystems. However, they suggested that there were few data available with which to assess whether the predictions being put forward were correct. They suggested that until proven, it was not realistic for such predictions to be an integral component for the stock assessment. Reviewer #2 suggested that the authors examine the relationship of lingcod catches to environmental indices prior to implementation of harvest restrictions. The same reviewer complimented the authors on their work on the potential impacts of climate on groundfish stocks, and suggested that they consider submission of papers to PSARC which directly address this issue.

Reviewer #1 noted the precipitous decline in lingcod catches in all areas since about 1995 and the fact that catches have not approached the allowable harvests in any of the areas over the past several years. He suggested that in the absence of comprehensive assessment data for these stocks, allowable harvests should be set at much lower and more conservative levels than is currently the case until such time that analytical assessments are conducted that support the current harvest levels. Given the apparent dynamics of this fishery it might also be useful to investigate some form of depletion estimator to model the dynamics of these populations.

Reviewer #1 endorsed the authors recommendation to re-instate the winter trawl closures in those areas where they have been removed.

Both reviewers recommended inclusion of a table detailing annual catches, quotas and recommended yields for 2000/2001 and, 2001/2002. Reviewer #1 also requested that the table include associated risk levels for all stocks and harvest areas. Reviewer #1 suggested that the authors include lines in Figure 3 denoting the median catch and effort values for the various time series of data

presented in these plots. Reviewer #2 also requested more elaboration on the data sources used in the assessment.

Subcommittee Discussion

The Subcommittee endorsed the request for stock assessment modelling approaches to be included in future assessments. The authors agreed. With respect to the references to the impact of climate-ocean regime considerations, the authors noted that the emphasis on the recruitment/regime shift relationship could be reduced in the document. However, they suggested that this issue merits more consideration than is typically provided in most assessments.

The authors agreed to include a table which summarized the recommendations for all stocks and agreed that an examination of the relationship between historical landings and regime shifts might be useful.

The Subcommittee noted that as historical data are uncovered during PSARC or other investigations, that an attempt be made to capture these within an overall catch data system. This would remove the need for future workers to repeat the same exercise.

The Subcommittee commented that the 1996 to 1998 hook and line catch data was incorrect. The authors will correct this and noted that it does not impact conclusions drawn from the trawl based CPUE index.

The Subcommittee suggested an examination of the utility of age/length keys given the difficulty and costs associated with the collection and ageing of fin rays, especially in light of the relatively high growth rate.

The Subcommittee endorsed the development of a Strategic plan to address adequacy and bias in groundfish sampling.

The Subcommittee recommended that the available length, age and CPUE data be used in a population dynamics model. This approach might be helpful for Areas 3CD and 5AB.

The Subcommittee recommended that the issue of winter closures of lingcod fisheries be examined both with respect to estimating the sex proportions in the fishery and examining the impact of this fishing on lingcod stock dynamics. The Subcommittee noted that the value of a winter closure on the fishery was dependent on the overall exploitation rate.

The Subcommittee commented that, as with other applications, comparability of CPUE over time was heavily influenced by area-specific effects, marketing, and optimisation of fishing strategies within the individual vessel quota (IVQ) constraints. Furthermore, the constraints imposed by IVQ management could act

to prevent attainment of the quota. Therefore, failure to attain the quota cannot necessarily be assumed to be reflective of low abundance as suggested by reviewer # 1.

The Subcommittee suggested that the final column in Table 4, indicating mean weight/trip in Barkley Sound, be omitted. It was derived from a constant estimate of mean weight in recent years and implies that the recent change in retention size has had no effect. The Subcommittee noted mean weight data might be obtained from the recreational charter fishery. The authors commented that they would examine this issue although these data were not easily obtained from the recreational fishery.

The Subcommittee noted that the 4B creel survey CPUE index in recent years was similar to levels at the beginning of the series. The shift in ratio between kept and released in the creel survey was probably a result of the implementation of the size limit change not a signal of incoming recruitment. Further, the lack of an increase in kept fish suggests there is no evidence of any sign of re-building.

Subcommittee Recommendations

1) The Subcommittee recommended acceptance of the paper subject to revisions. The Subcommittee agreed with the authors that the available information provided no basis for changing any of the previous harvest recommendations.

2) The Subcommittee recommended that the available length, age and CPUE data be used in a population dynamics model for the next assessment. This approach might be helpful for Areas 3CD and 5AB.

3) The Subcommittee recommended that the issue of winter closures of lingcod fisheries be examined both with respect to estimating the sex proportions in the fishery and examining the impact of this fishing on lingcod stock dynamics.

G2000-02: Sablefish stock assessment for 2000 and recommended yield options for 2001

V. Haist and R. Hilborn **Accepted subject to revisions**

Summary

The principle data source on trends in abundance is the tagging program, and in particular the percentage of tags returned in the year following tagging. Coastwide, this percentage remained steady at 9-11% from 1991 to 1997, rose to 19% in 1998, and decreased to 8% in 1999.

Three methods, all based on the tag release-recapture data, are used to estimate stock abundance. The methods differ in the degree that biological and fishery

structure is incorporated in the estimation process, and in the choice of tagging data subsets used in the analyses. Different tagging data subsets are chosen to minimize potential bias in the alternative estimation methods.

All three methods suggest that B.C. sablefish decreased in abundance from the early 1990s through 1997. This trend is consistent with observations in commercial fishery CPUE and survey indices. All three tagging methods indicate a substantial increase in the sablefish population in 1999. This was not apparent in the commercial CPUE or survey indices. However, the 1999 fishery CPUE is not adjusted for the effect of escape-rings used in the commercial fishery in 1999, and therefore will not reflect abundance trends.

Stochastic stock projections are conducted for the 2000 to 2002 period at three levels of harvest (3700 t, 4000 t, 4500 t). The expectation, at all harvest levels, is an increase in abundance for both stocks. Assuming an above average recruitment for 2000 increases the probability that the stocks will increase between 1999 and 2002. The Hecate Strait Inlets survey data suggests that the year-class(es) beginning to recruit to northern B.C. in 1999 are larger than the preceding three to four year classes.

Reviewers' Comments

Reviewer #1

This reviewer considered only the single year and multi-year tagging analyses, as the integrated catch analysis was not promoted by the authors. For the single year analysis, he suggested that justification and/or a source be provided for the choices of some key parameters and assumptions that are made. The text should be revised to make it clear that use of recovery data from only the first calendar year after tagging will result in abundance estimates of low precision but these should not be biased. For the multi-year analysis, he suggested that the data used in the analysis be presented better, the model fitting process be described more clearly and a conventional model be applied as a check on the Bayesian model. Inconsistencies in the data tables should be reconciled.

Reviewer #2

This reviewer identified four key concerns. The first was that the yield range choice of 3700-4500 was not justified and appeared arbitrary. The second was that the target harvest policy objective of maintaining population biomass greater than 25% of the unfished biomass represents a strategic choice that has not been established. Further, in another section, the text refers to maintaining spawning biomass at 40-45% of virgin biomass. The third criticized the emphasis on large incoming recruitment when the evidence only indicates that the recent recruiting year-class is better than those immediately preceding it, which may have been poor. The final criticism was that the sensitivity of results to the

reporting rate, a highly influential parameter, had not been thoroughly investigated. Some suggestions for doing this were provided by the reviewer.

Subcommittee Discussion

The available evidence suggests that there is limited movement between Northern and Southern components of the sablefish population. However, substantial numbers of tag returns from fish released in Northern B.C. are recovered in Alaska, though without standardization for fishing effort, interpretation is difficult. The potential impact of the Alaskan fishery on the Northern B.C. component was not evaluated. There are strong similarities in biomass trends for Alaska and Northern B.C., consistent with a mixed resource, but these could just as likely be due to parallel year-class strengths and dynamics that are driven by global conditions. It was recommended that estimates of migration rate to Alaska should be attempted and updated regularly to monitor these movements. Movement of sablefish from Southern B.C. to west coast USA appears to be much more limited and can probably be ignored. It was recommended that stock structure considerations be reviewed to evaluate options for stock assessment units and to determine practical management units. A comprehensive investigation may require a co-operative study that pools information from tagging in both Canada and USA.

The divergence in selection of tagging data for the single year recapture and for the multi-year recapture analysis was a concern but was not expected to introduce any important bias. It was recommended that the data sources be reconciled and made consistent. The exclusion of tagged fish from depths greater than 750m in the multi-year analysis should not bias results if there is good mixing.

Escape rings were required by regulation in 1999, and were used in all commercial sablefish traps. Escape rings were used by some fishers in 1997 and 1998, but the proportion of the catch taken with escape-ring traps is unknown. Interpretation of both CPUE and tagging data rely on accurate information about gear modifications.

Estimation of abundance from single year recapture is more robust to suspected movement to areas where fish are less vulnerable to the Canadian fishery. The estimation of mortality in the multi-year recapture analysis is likely to be confounded with this emigration and the associated partial recruitment to the fishery of larger/older fish. Some of these complications with the multi-year analysis might be accommodated by admitting negative "new" fish to account for decreased vulnerability. In this analysis, "new" fish represent recruitment and immigration/emigration effects.

The Subcommittee suggested that justification of Bayesian priors and investigation of their impact on results should be examined. The choice of fairly

well determined priors for some parameters, e.g. M, was questioned, particularly since the dispersion of the posterior was comparable but the central tendency had shifted.

Due to the potential impact of management measures on CPUE, this index has previously been rejected as reflective of abundance. Nevertheless, the CPUE can be indicative of broad events in the population, though recent values need to be interpreted with caution due to the introduction of escape rings. It was noted that some experimentation with escape rings started as early as 1997, with partial introduction in 1998 and full implementation in 1999.

Considering the results from single year or multi-year tagging analyses, CPUE trends and the Alaska assessment results, there is concurrence that the biomass declined from the late 1980s through to about 1995. Since 1995, biomass appears to be relatively stable with some indication of moderate improvement. With respect to 1980 to the present, the tagging results suggest that biomass is about average while the CPUE trends and the Alaska assessment results suggest that biomass may be below average. The Alaska assessment also offers a longer data series and biomass of the Alaskan stock is below average relative to this time frame. Examination of length composition information indicates that incoming recruitment is better than the recent poor year-classes that are currently in the fishery. Though this is a long lived species, surplus production appears to be driven by recruitment, the limited somatic growth of recruited fish being countered by natural mortality and reduced vulnerability of larger/older fish.

Reliable measures of incoming recruitment are not available. Because biomass growth will be dependent on recruitment, there will be a large uncertainty about the impact of alternative quota options for 2001. It should be noted that, in recognition of rebuilding concerns, the quota was adjusted downwards by 11% in 2000. Further, it is noteworthy that the catch has been relatively constant at about 4,000 t to 5,000 t over the past three decades. There was concurrence that catch quotas for 2001 in the range of 3,700 t to 4,500 t are not likely to result in measurable differences in the magnitude of the biomass for 2002.

Industry reported an increased incidence of juvenile sablefish encountered by the trawl fleet during July and August of 2000 in a band along the shelf edge. Detection of juvenile sablefish in previous years have been patchy and in isolated spots. These observations are encouraging, though these juveniles will not recruit to the fishery for some years.

Subcommittee Recommendations

1) The Subcommittee accepted this paper subject to revisions.

2) The Subcommittee endorsed the 2000/2001 yield recommendations.

3) Given the possibility for a distinct Southern B.C. stock and a single Northern B.C./Alaska stock, stock structure should be reviewed to determine practical management units.

G2000-03: Silvergray rockfish (*Sebastes brevispinis*) assessment for 2000 and recommended yield options for 2001/2002

R.D. Stanley and A.R. Kronlund **Accepted subject to revisions**

Summary

This document summarises the available information on the stock status of silvergray rockfish (*Sebastes brevispinis*) in British Columbia waters and provides yield recommendations for the 2001/2002 fishing year. It also summarises biological and historical fishery information so that future researchers will be able to use this document as the starting point for their assessment work on silvergray rockfish.

The available biological data are analyzed to provide recommended target harvest rates. The authors suggest that harvest recommendations for silvergray rockfish be based on a risk-neutral strategy of $F=0.75*M$ and a risk-averse strategy of $F=0.5*M$. Their best estimate of M is 0.06. Each of four stocks, corresponding to PMFC Area 3CD, 5AB, 5CD and 5E, were examined using catch-at-age analysis. Each stock analysis examined three general cases, where Case 1 examined the impacts of tuning with commercial CPUE and/or survey estimates; Case 2 fitted proportion-at-age data only, with variable recruitment and; Case 3, which was similar to Case 2, but forced recruitment to be constant to mimic simple catch curve analysis.

For Area 3CD, quota recommendations are based on the model tuned to a U. S. triennial survey which surveyed part of Area 3D and use a F=0.75*M strategy. The recommended risk-averse and risk-neutral harvest options are 150 and 224 t as compared with the previous "low-risk" and "high-risk" recommendation of 150-425 t. Quota recommendations for Area 5AB are based on a model run which fits ageing data and allows variable recruitment. The recommended risk-averse and risk-neutral harvest options are 214 and 319 t as compared with the previous "low-risk" and "high-risk" recommendation of 350-700 t.

For Area 5CD, the quota recommendations are based on a model run which fits ageing data and allows variable recruitment. The recommended risk-averse and risk-neutral harvest options are 96 and 217 t as compared with the previous "low-risk" and "high-risk" recommendation of 125-400 t.

For Area 5E, the quota recommendations are based on a model run which fits ageing data and allows variable recruitment. The recommended risk-averse and risk-neutral harvest options are 137 and 204 t as compared with the previous "low-risk" and "high-risk" recommendation of 175-300 t.

Reviewers' Comments

Reviewer #1

This reviewer commended the authors for clearly presenting this substantive and comprehensive piece of work. Comments fell into the five main topics:

1. Uncertainty in the ageing and its effect on the assessment topics. Presently, the model does not allow for uncertainty in ages. As a fish gets older, there is more uncertainty associated with the estimated age, i.e. more likely to mis-age the fish.
2. Whether the proportion-at-age samples are representative of the catch. For some age frequencies, there are large discrepancies between years indicating that they are not likely representative of the whole population.
3. The use of different models to generate the reference mortality and to assess the stocks.
4. The way that error is treated in the model results.
5. The basis on which particular model runs and model data are selected. This reviewer's personal experience suggests that the model requires a tuning index.

Based on the above concerns, the reviewer recommended that acceptance of the yield recommendations be deferred and that the analyses be viewed as a work in progress. Given the reviewer's disagreement with the model runs on which the yield estimates are based, the following recommendations should be explored before the present model is used to set quota limits:

1. The explicit inclusion of ageing errors into the model.
2. Inclusion of growth parameter estimations in the model.
3. That model runs be repeated using subsets of the proportion-at-age and CPUE data to more thoroughly test the sensitivity of the model results to the data inputs.
4. Use the assessment model to generate the equilibrium yield reference points.
5. Generate parameter and yield estimate uncertainties based on bootstrapping or Bayesian procedures.

The authors agreed that ageing uncertainty is a serious issue, but point out that the model can capture general year class trends. There is heterogeneity among the proportion-at-age samples, but research samples can be used to augment these fishery samples since the research surveys were conducted with commercial boats and attempted to fish on typical grounds, using typical gear. Presently, 4-6 samples are collected per stock and logistics on the processing of ageing structures is a limiting factor for additional ages. The authors noted that the present model can not solve the stock-recruitment function, but that it can be addressed in the upcoming year. However, the way that error is treated in the model results can not be resolved for this assessment. The authors pointed out that the available tuning index, CPUE, is not reliable for a fishery that uses

hydroacoustics to search for the fish. On a final note, the recommendation that the yield recommendations be deferred and that this be viewed as a work in progress, means that it will likely be viewed as a work in progress for several years. Historical limitations in proportion-at-age or other historical data can not be resolved. The model provides a best estimate of the current F, it does not provide projections. Falling back on previous recommendations implies that the 1995 assessment was superior, but it was not.

Reviewer #2

Several components should be clarified in the present assessment document:

1. The authors should provide some interpretation of the landings patterns, since the landings are stable in some areas, but exhibit unsustained increases in other areas.
2. Reference is made to a US survey. A description of the survey design is required.
3. The problems with the representativeness of the age compositions for the population. Enhancement of the age composition information may be possible by pooling over areas and applying an age-length key to increase age information using length data.
4. The rationale behind using a stock-recruitment curve for the estimation of reference points, but the exclusion of such a curve in the catch-age model needs to be explicitly stated.
5. The catch-age analysis portion of the assessment should examine the error associated with the modeled recruitment trends. In addition examine and report the parameter correlations, especially q_2. Explain the rationale for assuming a constant selection over all years.
6. The management advice presented in the assessment needs to explicitly define 'low', 'high', 'averse' and 'neutral' risk. Without clearly addressing Canada's management objectives, it is difficult to assess the selection of the spawner per recruit (SPR) reference points.

This reviewer suggests that improvements to the assessment of these stocks will require the improvement of information on fishery catch-at-age and the development of survey indices.

The authors did not use length frequency data for two reasons: 1) length data are not always available and the historical gaps correspond to gaps in age data and 2) the use of age-length keys was explored extensively in the late-1980s and could not be applied to rockfish. However, this approach could be revisited given that age classes have been fished down. The constant selectivity is likely applicable since there have not been changes in the fishery, such as changes in mesh size. The authors agreed that the different levels of risk do need to be clarified.

Subcommittee Discussion

The Subcommittee accepted the biomass calculations from the cases recommended by the authors. With respect to reviewer # 1's comments, it is recognised that stock assessments evolve with time and each one is a progress report on ongoing investigations. This cannot be used as a reason to defer advice. The Subcommittee requested that the authors provide uncertainty estimates for the corresponding terminal biomass levels. The Subcommittee requested that the authors add an F=M yield option to the options F=0.5M and F=0.75M.

Industry reported an increase in silvergray abundance in the last two years, especially in areas 5A/B and 5C/D/E. The authors pointed out that the industry was observing a recent increase in abundance or availability and that the model cannot track immediate increases without a tuning index.

The Subcommittee noted that any changes in yields that would result from this assessment can be attributed to two factors: 1) this is the first time that the current biomass has been estimated and 2) the application of new reference levels for fishing mortality.

The Subcommittee requested that the additional material presented during the meeting, concerning the implications of the maturity ogive on reference point calculations be included in the revised document.

Subcommittee Recommendations

1. The Subcommittee accepted the assessment paper subject to revisions. Revisions should include F=M yield option.
2. Attempts to increase the amount of age sampling should be made to address limited age data.

G2000-04: Stock assessment of rock sole and English sole in Hecate Strait for 2000/2001

J. Fargo, A.R. Kronlund, J. Schnute and R. Haigh **Accepted subject to revisions**

Summary

The authors summarize biological information and analyse catch-age data for stocks of rock sole and English sole in Hecate Strait. Their analyses use a state space catch-age model to reconstruct stock histories. Results indicate that recruitment and biomass of both species have declined over the last four years. In particular, recruitments in 1998 and 1999 reached historic lows for both species. The authors compare biomass estimates from the catch-age analysis with those obtained using swept-area expansions of commercial and research

survey catch rates. All analyses show similar stock trends, although the swept-area estimates show high variability. Equilibrium calculations are used to determine various fishing mortality reference points. These suggest lower, more conservative, fishing mortality reference points than those found in previous analyses. The authors estimate yield by applying a target fishing mortality to the 1999 estimates of biomass from the catch-age analysis. Current yield recommendations are reduced significantly from previous years. The yield range for rock sole is 600-700 t, while the yield range for English sole is 300-400 t. This information is synthesized to provide advice to managers on harvest levels for the 2001/2002 fishing year.

Reviewers' Comments

Reviewer #1

Reviewer #1 was concerned that truncating the analysis to ages 4 and older could bias the catch-age analysis. It was noted that a 4.5 inch mesh, used until 1996, was fully selective at age 4 and 50% selective at age 3. However, based on the growth curve and the size of retention (30 cm), many age 3 and some age 2 fish would be retained. The reviewer suggested it might be instructive to conduct an analysis which included younger fish from the surveys.

The reviewer also noted large variations in effort with limited changes in CPUE. This is peculiar and may reflect how effort and CPUE data are selected; the paper would benefit from a discussion of this. The reviewer also suggested that the assessment would benefit from a description of the procedure used to pool survey data with size selective fishing data to conduct the growth curve analysis. Since substantial growth occurs at younger ages, the time of year when samples were obtained could be used to refine the analysis.

Reviewer #1 requested the rationale for using Beverton and Holt or Ricker stock recruit curves to define reference points while an autoregressive recruitment process is used in the catch at age analysis.

The reviewer requested summary tables be included which could be a considerable aid in estimating stock status, including a survey catch at age table for both species. This could be helpful in determining abundance of pre-fishery recruits.

The reviewer noted that biomass trends in response to recruitment patterns suggest that yield advice should be based on projected population results. If recent recruitment is as low as suggested, biomass will continue to decline. Basing yield advice on the 1999 level without projecting forward could lead to higher than desired exploitation rates.

The reviewer had difficulty determining if the results and conclusions were

supported by the data and analyses. The extreme recruitment failure suggested by these analyses, if correct, may require a more severe management response than indicated. On the other hand, the survey information and age composition do not seem entirely consistent with such an interpretation. The imposition of an autoregressive recruitment process may impose spurious structure. If a simple or separable virtual population analysis including catch at age data at younger ages were calibrated to the abundance at age from the survey, the output could be used to diagnose the results from the catch at age model that has been applied. Equivalently, the catch at age model that was used could be modified to estimate the recruitment series as free parameters, expand the age range to younger ages and use age specific indices from the survey. The authors maintained that the survey and catch-age analysis were consistent with respect to recruitment trends.

Reviewer #2

This reviewer accepted the general conclusions of the paper that stocks are declining as a result of recent poor recruitment and that caution is warranted. However, the reviewer requested further explanation for the declines and reductions in the yield ranges. The drop in biomass is partially a result of changes in model formulation. The reviewer suggested running the old version of the model with the most recent data to examine the impact of model changes.

The reviewer suggested that the results of the current catch/age analysis appear reasonable for current abundance levels but had concerns with the reconstructed time series. These concerns centred on the trend in the commercial CPUE index and patterns in age proportion residuals. The reviewer believed the overall trend in the commercial CPUE was significant and this differed from the reconstruction trend (rock sole). Patterns in the age composition residuals for both rock sole and English sole suggest problems with ageing or with specifications of the population dynamics. The authors disagreed that there were patterns in the age proportion residuals.

Reviewer #2 concurred with reviewer #1 in that the range in yield options was calculated using a new set of reference points, for which the underlying rationale is quite different.

Subcommittee Discussion

The Subcommittee concurred with the detailed comments of both reviewers. Subcommittee discussion focussed on the choice of the selectivity function, representativeness of biological data, reliability of CPUE data, recruitment indices, and the calculation of reference points. Industry representatives cautioned that we must be confident that biological samples used in the analysis were representative of the whole stock. It was suggested that a review of sampling requirements and protocols be undertaken to ensure biological samples

were representative (this applies to all species/assessments). The Subcommittee acknowledged that the commercial CPUE index may be biased by fishing practices (avoidance) and selectivity (mesh size, regulations, etc.). Industry representatives noted that the assessments were not consistent with their observations of English sole abundance but were consistent for rock sole.

Subcommittee Recommendations

1. The working paper is accepted subject to revisions requested by the reviewers. The reference points should include F=M and F=0.75M yield options, and the historical $F_{0.1}$ yield options.

2. The Subcommittee supported the authors recommendations that assessments should be conducted on these stocks in 2001.

G2000-05: Estimating stock biomass from tow-by-tow data for Pacific groundfish

J. Schnute and R. Haigh **Accepted subject to revisions**

Summary

This paper describes a systematic approach to estimating groundfish biomass from swept area density measurements. The resulting estimates might be used as relative or absolute abundance indices, depending on the context. Conceptually, the idea is simple. Tows provide estimates of biomass density. Habitat area can be estimated from bathymetry, locations of fish capture, and other sources of information. Multiplying the density by the area gives an estimated biomass. The authors present a rigorous description of one possible method, along with a bootstrap technique for assessing uncertainty. They also illustrate advantages and limitations to the approach, based on data from research surveys and commercial fisheries. In particular, they use records from over 100,000 tows in the groundfish observer database. Despite limitations, biomass estimation methods play an important role in groundfish stock assessment. Surveys inevitably require some method of analysis, and comparisons between the commercial fishery and surveys offer insights into the fishery. For example, current data are consistent with an industry claim that two flatfish species experience different fishing patterns, distinguished by targeting and avoidance. The analyses here highlight issues of considerable scientific importance, such as the need to obtain better habitat definitions. Furthermore, they provide a useful starting point for designing a survey sponsored by the groundfish industry.

Reviewers' Comments

Both reviewers agreed with the concept of using swept-area estimates as an index of abundance. However, both reviewers concluded that bias caused by

differential effects of various gear configurations and unknowns associated with catchability preclude an absolute abundance estimate. Reviewer #1 thought issues of herding and species-dependent net avoidance behavior make it difficult to determine catchability. Reviewer #2 also pointed out that management restrictions (eg. area and time closures, limiting TACs) may affect CPUE and are not accommodated by the methodology. The calculation of area was identified as a critical issue, not only in terms of determining the appropriate area for expansion, but also in the choice of grid size used to compute density. In consideration of the degree of variability, reviewer #1 suggested that among year changes in the computed biomass estimates may be due to changes in fishing behavior rather than changes in stock abundance. Although the structure of data from commercial and survey sources is similar, the data are derived using quite different processes and commercial data are not necessarily representative of habitat. The reviewers thought that different treatments of the data from each source should be explored.

Both reviewers commented on potential bias in the computation of an absolute estimate that relies on a trimmed mean, although they agreed that it may not cause problems for a relative abundance estimate. Alternative approaches using model-based estimators and distribution assumptions such as Delta, Poisson, or log-normal errors might be worthwhile. Generation of confidence bounds using bootstrap methods was endorsed although reviewer #1 noted that for survey data, the bootstrap procedure should reflect the survey design. Reviewer #1 recommended adoption of the bias-corrected bootstrap procedure to correct for acceleration. Finally, reviewer #1 suggested that incorporation of catch data into the estimation process would help to provide scale. Reviewer #2 suggested that closer examination of cases where there was divergence between survey and commercial results, or divergent estimates by season may help in developing the technique. Reviewer #2 also noted that the area of expansion for Hecate Strait assemblage survey should be commensurate with the intended area of coverage of the survey. Reviewer #1 concluded that it was difficult to comment on the results and recommendations because it was unclear whether the authors had concluded that application of the method was successful and that results should be used in making harvest recommendations.

Subcommittee Discussion

The authors pointed out that unexplained shifts in abundance estimates provide grounds for discussion with management and industry. They recognized that their results reflect fishing patterns, as well as stock abundance. Consequently, their analyses offer a framework for investigating interactions between fishermen and fish. Apparent anomalies in the CPUE trends could reflect different management regimes. For example, rock sole biomass estimates in recent years appear higher from commercial data than from research survey data. This relationship is consistent with the industry observation that the fishery targets this species. By contrast, the situation is reversed for English sole. Biomass

estimates from commercial data are smaller than corresponding survey estimates, consistent with the industry claim that the fishery avoids this species. It was suggested that when the quota is sufficiently high, the trawl fleet can effectively target rock sole and produce high catch rates. A lower quota for English sole causes avoidance behaviour by the fleet, and commercial catch rates fall below those in the survey. However, the situation may not always be as simple as targeting-avoidance, because some fishermen try to optimize the mix of species caught as dictated by their quota holdings.

Information on targeting was identified as a potential useful auxiliary variable, although no specific plan for utilizing such data was discussed. It was pointed out that adopting approaches that relied on distributional assumptions and structural models (eg. GLM, GLiM, GAM) invite bias due to error and model mis-specification, respectively.

Subcommittee Recommendations

1) The Subcommittee recommended acceptance of the paper subject to revisions. The Subcommittee endorsed the approach as a means of investigating patterns in commercial and survey indices.

G2000-06: Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis*) for 2000

P. Starr and R. Haigh **Accepted subject to revisions**

Summary

A detailed compilation and analysis of the available data for longspine thornyheads (*Sebastolobus altivelis*) found in west coast Canadian waters is presented. This analysis was prompted by concerns over the rapid development of a new bottom trawl fishery directed at this species since 1996. An analysis of the available length frequency data from the commercial fishery showed that these distributions have been quite stationary over the four years of the fishery. Relative abundance indices estimated from CPUE data using general linear modelling methods showed a 16% decline in biomass over the four year history of the fishery. Population modelling using a dynamic age-structured model fitted to the estimated relative biomass indices and the annual observations of length structure in the commercial fishery estimate that the population has declined between 10 and 30% over the four years of the fishery. These estimates are unreliable due to the lack of a validated growth function and uncertain estimates for natural mortality. This report recommends the development of an independent biomass survey for this species and further research on growth rates. This report also hypothesizes that this species may have very wide stock boundaries due to its extended pelagic larval phase (18-20 months) and the consequent opportunity for wide dispersal due to prevailing ocean currents.

Recommendations

The following recommendations flow from this work:

1. Review the information being collected on this species from the commercial fishery. This includes information associated with the catch (including tow speed, vessel and net characteristics) and the biological information (length frequency, age frequency, sex and maturity). Recommend improvements to the collection of data based on this review.
2. Review available information on growth and ageing for this species. Commission further research on growth and ageing based on this review.
3. Design and develop a fishery-independent biomass survey.
4. Review available information on stock identification for this species. Commission research as required to determine the effective stock boundaries for this species.
5. Allow the current level of removals to continue for at least another year. Continue the present policy of spreading the catches throughout the entire coast.
6. Update for the 2001 PSARC meeting, the monitoring analyses (length frequency and GLM) presented in this report for the southern fisheries. In addition, summarise the length frequencies and catch rates from the exploratory fishery and compare these with those from the established southern fishery.

Reviewers' Comments

Both reviewers acknowledged the extensive compilation of thornyhead biological and fishery data. They also recognised that this assessment involves the highly uncertain conditions of an emerging new fishery.

Reviewer #1

The first reviewer expressed the view that the assessment model appears too complex, given the limited time period of data available from this fishery. He also wondered how the model results pertained to policy formulation and yield recommendations. Although the five recommendations make sense, they may not address the most pressing questions for management at this time. His review included numerous technical comments on the analysis, based on CPUE from experienced fishermen. These individuals might be able to maintain high catch rates in the face of a declining stock. The generalised linear model analysis of CPUE data has not been tested for confounding factors, such as vessel and depth. The assumed value of natural mortality (M=0.1) may be too high, as suggested also by better model fits with M=0.05.

Reviewer #2

The second reviewer expressed concern for the use of invalidated ages and the use of length distributions that may be uninformative for long-lived fish. Given these concerns, the length based age-structured model used here is inappropriate. She expressed strong support for research into ageing methods, as proposed in Recommendation #2, but cautioned that validation procedures will also be required. The assessment concludes that there is little evidence that the fishery is having a large impact on the vulnerable biomass of the species. Given the high uncertainty in model results, one could equally argue that there is little evidence that the fishery is not having a large impact. Furthermore, in this emerging deep water fishery, bycatch might be used to examine possible ecosystem impacts.

Subcommittee Discussion

Estimates based on CPUE data suggest that the abundance in 3C and the southern part of 3D has been depleted from the initial 1996 biomass, prior to the major development of this fishery. The best estimate (case 1 in the paper) indicates that the current abundance is about 82% of the 1996 biomass, corresponding to a removal rate between 4% and 5% per year. From current knowledge of species biology, this doesn't appear to be an excessive depletion rate in the short term. Given that this is a relatively new fishery presumed to be in the initial fishing down phase, future quotas may have to be reduced as the stock reaches optimal spawning biomass. The Subcommittee noted that this species is receiving significant research focus.

Participants noted that industry and management initiatives have been taken to redistribute effort which may offer some protection to the southern portion of the coastwide stock. Previous to the current fishing year, most of the catch had been taken in 3C and the southern part of 3D. The coastwide total allowable catch (TAC) was reduced by 50% to 425 t for the 2000/2001 fishing year. A 425 t experimental fishery was implemented in the northern part of 3D, 5AB and 5E. Industry agreed to participate in an extensive biological sampling program. A protocol was developed, monitored, and adjusted to ensure appropriate sampling levels.

The PSARC Invertebrate Subcommittee noted the by-catch of tanner crab in this fishery (CSAS Proceedings 2000/011). Minutes of the subsequent RMEC Meeting (July 4, 2000) direct "Science and Fisheries Management to form a Working Group to look at species interactions". The Subcommittee concurs with this initiative.

Subcommittee Recommendations

1) The Subcommittee recommended acceptance of the paper subject to

revisions.

2) The Subcommittee endorsed the recommendations in the working paper provided that monitoring of longspine thornyhead stocks continue.

G2000-07: Design of a bottom trawl survey for three slope groundfish species in Canadian waters

P. Starr and C. Schwarz **Accepted subject to revisions**

Summary

A feasibility study for a research survey using commercial bottom trawl gear targeted at three slope groundfish species located in the Pacific coast of Canada is presented. The objective of the survey is to generate comparable indices of population size over time which can be used as inputs into population assessment models for each of the three species. The recommendations are based on a detailed analysis of the variability in catch per hour for each species from commercial catch and effort data to determine the amount of stratification by depth and the number of tows required in each stratum to achieve a target level of precision. Of the three target species, longspine thornyheads appeared to be the least variable in commercial CPUEs and hence required the fewest tows to monitor the population. Shortspine thornyheads were of intermediate variability and pacific ocean perch were highly variable. Pacific ocean perch have a completely separate spatial distribution from the two thornyhead species and can be monitored independently. The two thornyhead species are spatially commingled, with shortspines having a more shallow distribution compared to the longspines. The final size and aerial extent of the survey will be dependent on the level at which each species is required to be monitored. These decisions are largely management based or require additional stock boundary research. Several alternative options for number of strata and suggested levels of precision are presented, ranging from under 150 tows to nearly 400 tows for the entire survey, with estimated costs varying from ~$275,000 to nearly $800,000. An additional issue is that the performance of the nets while towing must be monitored electronically to ensure comparability both within and among surveys as it is likely that net efficiency will improve over time.

Recommendations

The following are the recommendations for a slope rockfish survey:

1. Implement a survey directed at longspine thornyheads (LST), shortspine thornyheads (SST) and Pacific ocean perch (POP) to be initially undertaken in the 1 April 2001–31 March 2002 fishing year.
2. Stratify the survey into three depth strata, each targeted at one of the survey target species: 101-400 m (POP); 401-800 m (SST); and 801-1200 m (LST).
3. Geographical stratification will depend on management requirements and

biological stock definitions. It is recommended that the survey be confined to the west coast of Vancouver Island in the first year to test the feasibility of the survey design and to concentrate on implementation issues rather than on extending the coverage to a wide area.

4. Delivery of the survey can be accomplished by either of two models:

   a. Charter one or more commercial vessels to undertake the required number of tows. This model presumes the presence of one or more scientific technicians on board the vessel to collect the requisite scientific information associated with each tow; or,

   b. Allocate the required tows to actively fishing commercial vessels which will undertake one or more research tows during every fishing trip. This model presumes that the scientific observers currently required to be present on all slope rockfish trips will collect the requisite scientific information associated with these research tows.

5. Tows within each stratum will be allocated randomly according to the protocol specified in Section 7.3.1 of the working paper. Every research tow will be standardised as much as possible with respect to: a) tow speed; b) distance and direction towed; c) net characteristics including cod-end mesh size, door-spread and headline height.

6. Every research tow will require the monitoring of the amount of time the net is in contact with the bottom. Additional monitoring of the spread of the doors and the amount of material in the cod-end would also be desirable.

7. Direct experimentation to test some of the assumptions inherent in survey methodology would be desirable. Such experiments could include the reproducibility of catch rates from successive tows and experimental depletion of populations in restricted fishing areas. Such experiments would require specialised design before being undertaken.

Reviewers' Comments

Reviewer #1 was critical of the work and would not have confidence in the findings unless considerable revisions were undertaken. The reviewer felt considerable work was required on reducing the complexity and improving the organization of the paper and reported two major concerns. First, the linear model analysis of the commercial CPUE has many deficiencies and requires more details for the reader to understand the analysis. Second, the material on survey design is deficient and contains errors.

Reviewer #2 provided an extensive review that concluded the paper does not form the basis to proceed with the surveys as recommended, although it could serve as a foundation for elaboration of a specific survey design. The reviewers major concerns are as follows:

- The authors recommend that a survey be conducted in the 2001/2002 fishing year for the three target species, but suggest that the geographic extent be confined to the west coast of Vancouver Island. The choice of the west coast of Vancouver Island over possible alternatives is not defended.
- Depth stratification is recommended however no guidance is provided for geographic stratification.
- The authors suggest that the tow positions be randomized and that net performance characteristics be measured for each tow. Two delivery modes are proposed. The first relies on charter vessels while the second contemplates allocation of one to several survey tows to each commercial fishing trip. The preferred delivery option is not identified.
- Further development of temporal stratification is required.
- Direct experimentation in the form of examining short-term variability in catch rates and depletion of populations in experimental areas are recommended, but design considerations for these manipulations are deferred. This needs to be developed.
- The authors need to consider the previous literature available on trawl surveys, and specifically on trawl surveys of rockfish.
- There is no discussion of how catches will be sampled when it is not possible to process the entire catch.

Subcommittee Discussion

In presentation of the paper, the authors suggested that the title of the paper be changed from "Design" to "Feasibility of a bottom trawl survey for three slope groundfish species in Canadian waters". Subcommittee discussion centred around suggestions for improving the paper and the development of a process for continuing the design and implementation of the survey. The Subcommittee cautioned that the first survey would largely be a learning exercise.

Some of the suggestions for further consideration included:

- The coefficents of variation (CVs) examined in the document are all based on commercial data that could have problems, in particular in the case of POP, with avoidance fishing. It was suggested that the authors examine research survey data available for POP.
- In addition to examining quota regions, a habitat based area stratification should be considered. Geographic variation warrants further consideration. Specific grounds may be identified.
- More realistic costs be included when the survey is designed.
- Numerous survey design issues related to timing need further examination, in particular survey duration, season timing and inter-annual comparisons.
- The proposed upper depth limit of survey (100m) would encompass a large number of shelf species which may increase the benefits from this survey.

- It was suggested that U.S. triennial surveys and stock reconstruction trajectories could provide an opportunity to compare estimates of inter-annual component of survey variance (inter-annual variation in catchability).
- Consider the trade-off in variation reduction achieved with longer tow duration and the number of tows possible in a cost-benefit analysis.
- Further examination of assumptions and potential research related to trawlable versus untrawlable habitat.
- The authors should consider alternative designs for example, fixed station in addition to the random stratified.
- Should be aware that process errors may add significant variability to the measurement error of the survey.

Subcommittee Recommendations

1) The Subcommittee recommended acceptance of the paper subject to revision.

2) The Subcommittee continues to support the development of a survey directed at slope rockfish. However the Subcommittee did not endorse the recommendation to proceed with slope rockfish surveys pending the development of specific survey objectives and design.

3) The Subcommittee recommended the development of a joint DFO/industry working group to develop survey objectives, design, and analysis.

G2000-08: Assessment of Pacific cod in Hecate Strait, Nov. 2000

A. Sinclair **Accepted subject to revisions**

Summary

Annual total allowable catches (TACs) were introduced for Pacific cod in area 5CD in 1992. These were managed on a calendar year basis until 1996. Beginning with the 1997-98 period, the fishing year was changed to April 1 to March 31. The 1992 landings exceeded the TAC by about 50%. Since then, the landings have been below the TAC with between 41% (1994) and 85% (1998/1999) of the TAC being landed. In 1999/2000, 58% of the TAC was landed and so far in the current fishing year, only 31% of the TAC has been landed (as of Nov. 2).

The commercial fishery is the main source of information on trends in stock size. Two stock biomass indices were calculated. One covered the period 1954-1995 and was based on quarterly commercial catch per unit effort, an index of stock density ($t \cdot hr^{-1}$). The second index was based on a swept area method and used estimates of both density and area fished to produce an index of stock biomass. This index covered the period 1994-2000, the years for which set-by-set fishing

data are available. The long index indicated three periods of high Pacific cod biomass in area 5CD, the mid-1960s, mid-1970s, and the late 1980s. The last peak was followed by a decline to its lowest value in 1995. The shorter, swept area index indicated that biomass declined even further during the late 1990s and reached a minimum in 2000.

It has been suggested that changes in the management regime from an unrestricted fishery (prior to 1992) to global TACs (1992-1995) and then to individual vessel quotas (1996 – present) and the increase in regulated mesh size has affected the underlying relationship between commercial catch per unit effort and stock biomass. Of particular concern is that fishermen will avoid a potentially limiting species early in the fishing season in order not to run out of one quota before catching all available quotas. The set-by-set database of fishing activity in area 5CD between 1991-2000 was examined for shifts in fishing location and depth away from cod habitat as well as for changes in the frequency of occurrence of cod in individual trawl catches. There was little evidence that fishing effort has shifted away from areas preferred by cod. In fact, there may have been an increase in fishing effort in Pacific cod habitat in recent years. The frequency of occurrence of cod in individual fishing sets was higher in the period 1998-2000 than in the mid-1990s. Of the total fishing effort in area 5CD, a higher proportion has been expended in the depth zone preferred by cod in recent years than in earlier years.

A management framework consistent with the Precautionary Approach for fisheries management was proposed for this stock. Consider the state of a fish stock in terms of biomass (B) and fishing mortality (F). The Target Zone for stock status would be where the B ($B > B_{msy}$) and F ($F < F_{msy}$) reference points are met. If the B target was met but $F > F_{msy}$, the stock would be in a state of Overexploitation and steps would be needed to reduce exploitation. If $B < B_{msy}$, the stock would be in an Overexploited state and steps would be needed to promote stock rebuilding. There is a lower limit for stock biomass below which there would be serious concern for stock viability and this status would be Unacceptable. At this level, a serious commitment to stock rebuilding would be needed. A fifth state is also possible if F is Unsustainable (i.e. $F > r$ in the Graham/Schaefer surplus production model).

A non-equilibrium surplus production model (ASPIC) was used to estimate key stock parameters including biomass trends, fishing mortality, and biological reference points (F_{msy} and B_{msy}). The results indicate that the stock is currently at an extremely low biomass. Despite low catches in recent years, the current level of exploitation may not be sustainable and will certainly not allow any appreciable stock recovery.

Uncertainties regarding stock size were used to determine the probability of various stock levels not being achieved given specific catches in 2001. This analysis used output from the surplus production model and as such included

uncertainties in the fitting procedure conditioned on the model assumptions. Uncertainties associated with model mispecification and errors in assumptions were not included. Three outcomes were considered, that stock biomass would decline, that stock biomass would not increase by 10%, and that stock biomass would not increase by 20%. These were chosen because of the extremely low stock biomass and the assumption that a management objective is to rebuild the stock. The probabilities of these three events were calculated over a range of 2001 catches of 0 – 700 t. The catches associated with a 50% probability correspond to the respective deterministic catch projection.

A catch of approximately 250 t corresponded with a 50% probability of stock biomass declining (Fig. 1). A catch of 150 t had a 20% probability of stock decline. A catch of 135 t had a 50% probability of stock biomass not increasing by 20%, while a catch of 75 t had only a 20% probability of the biomass not increasing by 20%.

This presentation of yield options covers a much larger range than what has been presented in the past. Managers are free to determine what yields they consider to be of high or low risk.

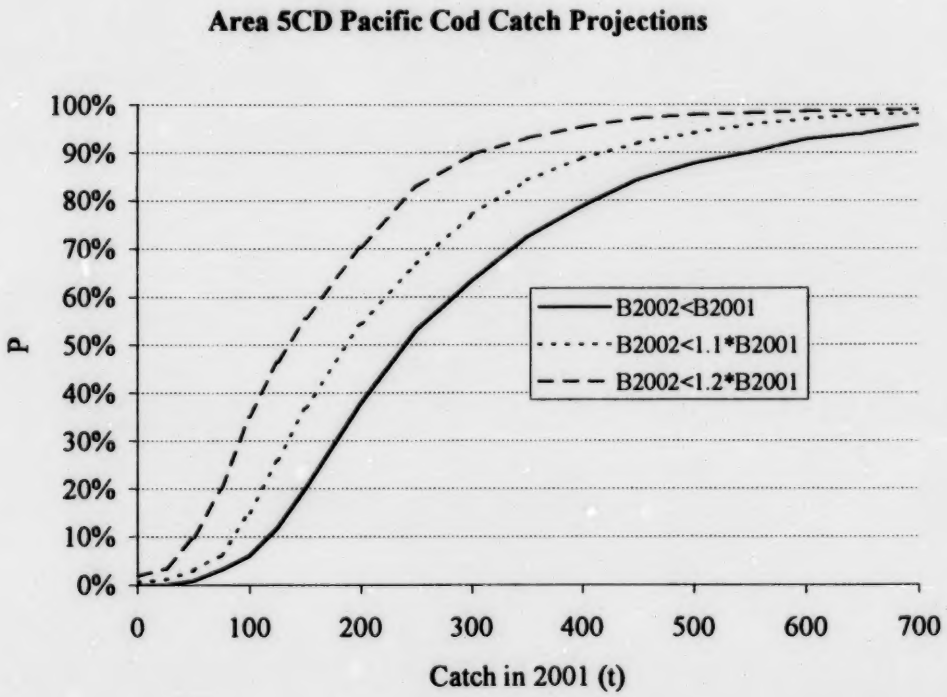

Figure 1: Probability of stock biomass declining (solid line), stock biomass not increasing by 10% (dotted line) and stock biomass not increasing by 20% as a result of a range of catches in 2001.

A 10-year stock projection which assumes no catch indicates that there is a 50% chance that stock biomass will not recover to the Target Zone. A moderate fishing mortality rate of 25% F_{msy} for 10 years would increase the probability that the target zone would not be achieved to 75%. Catches in the initial years of such a scenario would be about 50 t.

Recommendations

1. Current catches, even though well below TACs, threaten the stock's viability. The current fishing mortality is unsustainable. Steps are needed to reduce fishing mortality to a level well below what would be considered acceptable if the stock were in the target zone.

2. Cod are widely distributed throughout area 5CD and a large proportion of the current catch is taken as by-catch in fisheries directed toward other species. The trawl fishery, which takes almost all of the Pacific cod catch in this area, is relatively unselective for individual species. It may be necessary to close a large portion of Pacific cod habitat to fishing in order to achieve the required reduction in catch.

3. A research program will be required to monitor stock status during the period of closure.

4. Research is required on the distribution of other species in area 5CD and how these species will be affected by such closures.

5. If fisheries for other species are to continue, research is required on alternative fishing technologies that will limit the catch of Pacific cod.

Reviewers' Comments

Reviewer #1

Reviewer #1 concurred with the author's acknowledgment of uncertainty in the use of CPUE as a proxy for abundance. The advice given here is dependent on the assumption that CPUE is proportional to abundance. Fishing power and factors unrelated to abundance, such as regulatory measures and market influences, have changed over time. Fishing power could be standardized over the time series. However, the various socioeconomic effects can not be discerned. The CPUE series contains less contrast than the stock biomass index from the previous catch-age analysis. This is an indication that CPUE may not be proportional to stock biomass.

The surplus production model assumes that this is a closed population and that recruitment and growth are constant. There may be significant immigration-emigration occurring in this population. Recruitment of Pacific cod is highly

variable yet the model cannot accommodate the observed variability. In addition, the model does not account for the influence of the environment, changes in biological characteristics such as size at age and maturity at age or a stock-recruitment relationship.

In spite of these model criticisms, Pacific cod landings in this region have been very low for the last seven years and the biomass trend from this analysis is similar to those from past analyses. Reviewer #1 would like to see rebuilding simulations for this population that incorporates what is known about growth, natural mortality, immigration-emigration, stock-recruitment and environmental influence.

Reviewer #2

Reviewer #2 stated that the working paper is well written and reports a thoughtful and effective stock assessment with valid conclusions and recommendations. The objectives of the paper are stated, conclusions are supported by the data and methods, data and methods are described in sufficient detail to evaluate the conclusions, the recommendations are provided in a useful form for managers and the advice generally reflects the uncertainty in the data and analysis. Reviewer #2 suggests the following that may improve assessment abilities:

1. Reviewer #2 is critical of the management framework. PSARC should consider the technical inaccuracies of the framework and the inconsistency with Precautionary Approach (PA) guidelines.
2. Overall, reviewer #2 feels that the limitations of production model results and sensitivities have been well documented and are appropriately considered in the conclusions. However, there are several aspects of the analysis that may require further consideration:
   a) The restrictive dynamic range of the data and the resulting estimate of reference points. The stock was not at Bmsy in the observed series and only 45% (0.9/2) of the dynamic range was observed. The cost of a restricted dynamic range is poor estimation of reference points, particularly K and Bmsy. The estimation of Bmsy is poor and the estimate is likely to change substantially as the stock grows.
   b) Agreement between the previous analytical assessment results (MULTIFAN) and ASPIC results is somewhat reassuring that the estimates of survey q are accurate. However, the divergence in stock size estimates in the most recent years is worrisome. There is equivocal evidence about recent trends in stock size, more work is needed to accurately interpret the differences. It would be valuable to update the MULTIFAN analysis to 2000 to confirm the earlier results. Despite this uncertainty, the general conclusion about stock status (B<<Bmsy) is valid and robust to these minor model differences.
3. Reviewer #2 stated that the disadvantages and pitfalls of using commercial catch rates as indices of stock size are well described in the paper. However,

several items may be considered in the future:

a) The addition of area or depth effects to the multiplicative model may help standardize differences in fishing behaviour (e.g., area closures, shifts to deeper water).
b) Area swept biomass indices may be sensitive to rectangle areas and more exact values may improve the analyses.
c) Consider depletion in the approach. Calculation of area swept appears to assume that the same bottom was not fished twice.

Reviewer #2 concluded that the assessment is effective for providing advice on fishery management. Despite some challenges with data limitations, the methods and interpretations are technically sound.

Subcommittee Discussion

Subcommittee discussion revolved around the issues of whether CPUE is proportional to abundance and the appropriateness of the surplus production model. CPUE is the only long term data set available for use in the assessment. Changes in regulations have compromised the series, making it difficult to interpret. Industry does not support the use of CPUE as an index of Pacific cod abundance, but they do not contest that current abundance is low. The Subcommittee was in agreement that all available indicators suggest very low levels of abundance. The use of a surplus production model was questioned, primarily due to the violation of the model assumption that recruitment is constant. The restricted dynamic range of the model predictions was also troublesome. Pacific cod is a highly recruitment driven stock and the age/length structured model used in the previous assessment should be in the next assessment. The stock trends are similar between the two approaches, however, they diverge in the years 1995-98, the last years in the previous assessment. The age/length structured model requires updating with new data collected since the last assessment.

The symmetric production model used here may not be appropriate for this highly productive species. Alternative model formulations should be considered. The interaction of K and r is scaled relative to the biomass at the start of the series. Since K is not B_0 for this stock, the scaling is uncertain in the model. The K and r parameters are often correlated in production models which adds to the uncertainty of the model results.

There is evidence that the stock is at an unprecedented low level of abundance. Model predictions indicate that the stock will not rebuild under current fishing effort, catches or the TAC. Enough of the stock needs to be preserved to allow rebuilding when recruitment conditions are favourable.

Subcommittee Recommendations

1. The working paper is accepted with some further work requested in a revision as follows:
   a) conduct forward simulations under various harvest scenarios
   b) present to managers the probabilities of no increase, or growth, in stock size at given catch levels
2. Harvest reductions are necessary to maintain current biomass and further reductions would be required to achieve rebuilding.
3. Improvements to the stock assessment model, incorporating more of the stock dynamics of Pacific cod, need to be added for the 2001 assessment.

Two presentations were made to the Subcommittee related to the effect of climate and regime changes on the provision of stock assessment advice.

Sablefish Report Card

J. King

A report card approach for the interpretation of ocean-climate effects on stock production and assessments was presented. Climatic, oceanographic and biological indices were used to evaluate the relationship between sablefish year-class success and ocean climate conditions. This was presented as a preliminary model for moving forward in ecosystem approaches in fisheries management.

Consideration of Regimes in Providing Stock Assessment Advice

R. Beamish

This presentation was made to raise awareness of the considerable literature describing the existence of climate regimes and the impacts these have on ecosystem dynamics and fishery production. The intent was to initiate discussion of regime influences for stock assessment. Numerous indices have been devised that measure climatic changes and act as indicators of regime shifts. Regimes are real, and when they shift, we must acknowledge that ecosystems change even though we may not know the dynamics.

Key points from the presentation were that regimes 1) are persistent, 2) have a planetary basis, and 3) reorganize ecosystems. Discussion of regimes and their use in future assessments has not been seriously considered to date. To incorporate the concept of regimes into stock assessments we need to know how individual species are affected by these changes.

Subcommittee Discussion

The Subcommittee noted that this model for sablefish is not intended to form the basis for stock assessment advice for sablefish for 2000. The Subcommittee noted the potential benefits of developing approaches that incorporate regime or ocean-climate indices into stock assessments. Discussion focused on the inclusion of regime information in assessment modelling, with caution that modelling assumptions may be a problem and should be assessed. Knowing when the environment has changed is useful in modelling stock status. The Subcommittee pointed to the fact that we must continue to deal with species biology even when regime influences are included in future models.

The Subcommittee recommended that a working group be established to develop an approach to incorporate ocean-climatic indices into stock assessments, transfer relevant data and discuss the implicit assumptions made in stock assessment models that incorporate mechanisms that may be driving fishery/stock dynamics.

Appendix 1: PSARC Groundfish Subcommittee Meeting Agenda, November 21-24, 2000

Agenda

Date/Time	Item	Authors	WP
Tues-Nov-21-2000			
10:00	Introduction/Welcome		
10:30	Estimating Stock Biomass	Schnute	
11:30	Pacific Cod in Hecate Strait	Sinclair	
12:00	Lunch		
13:00	Pacific Cod in Hecate Strait cont'		
15:30	Silvergray Rockfish Coastwide	Stanley	
Wed-Nov-22-2000			
09:00	Longspine Thornyheads	Starr	
12:00	Lunch		
13:00	Sablefish	Haist	
Thurs-Nov-23-2000			
09:00	Slope rockfish Survey	Starr	
10:30	Coffee		
11:00	Lingcod, all areas	King	
12:00	Lunch		
13:00	Lingcod, cont'	King	
14:00	Hecate Strait Rocksole and English Sole	Fargo	
Fri-Nov-24-2000			
09:00	Sablefish recruitment report card	King	
09:30	Consideration of regimes in providing advice	Beamish	
10:30	Report Review		
18:00	Meeting Adjourned		

Appendix 2: Participants at Groundfish Subcommittee Meeting, November, 2000

Subcommittee Chair: Alan Sinclair
PSARC Chair Max Stocker

DFO Participants	Association	Tues	Wed	Thurs	Fri
* Subcommittee Members					
Beamish, D.	Science	✓			✓
Beaith, B.	Science	✓	✓	✓	✓
Bedard, T.	Operations		✓	✓	
Choromanski, E.	Science		✓	✓	
Clark, D.	Operations	✓am	✓am	✓am	
Cooke, K.	Science	✓	✓		
Dunsmore, G.	Operations	✓	✓	✓	✓
Fargo, J.*	Science	✓	✓	✓	✓
Gillespie, G.	Science	✓	✓		
Haigh, R.	Science	✓	✓	✓	
Haist, V.*	Science		✓	✓	✓am
Joe, J.	Operations		✓		
Joyce, M.*	Operations	✓	✓	✓	✓
Kieser, R.	Science	✓			✓
King, J.*	Science	✓	✓	✓	✓
Krishka, B.	Science	✓	✓	✓	✓
Kronlund, R.*	Science	✓	✓	✓	✓
MacDougall, L.	Science			✓	
McFarlane, S.*	Science	✓	✓	✓	✓
Rutherford, K.	Science	✓	✓	✓	✓
Saunders, M.*	Science	✓	✓	✓	✓
Schnute, J.*	Science	✓	✓	✓	✓
Schon, H.	Science	✓	✓	✓	
Schweigert, J.	Science	✓	✓	✓	✓
Stanley, R.*	Science	✓	✓	✓	✓
Surry, M.	Science			✓	
Trager, D.*	Operations		✓	✓	✓
Workman, G.	Science	✓	✓	✓am	
Wyeth, M.	Science		✓		
Yamanaka, L.*	Science	✓	✓	✓	✓
External Participants					
Fraumani, B.	F.A.S. Seafood Producers		✓		
Healey, D.	Hook and Line Advisory Council			✓	
Hilborn, R.	CGRCS[1] and PBCFA[2]		✓		
Nyce, H.	Nisga'a Fisheries	✓			
Koolman, J.	Hook and Line Advisory Council	✓	✓	✓	✓
March, D.	CGRCS			✓	
Mose, B.	CGRCS		✓	✓	✓

Olsen, E.	GTAC[3] and SAC[4]		✓		
Roberts, C.	Conservation Society	✓	✓	✓	
Schmidt, D.	Quatsino First Nation	✓	✓	✓	
Starr, P.	CGRCS	✓	✓	✓	✓
Turris, B.	CGRCS and CSA[5]	✓	✓	✓	✓
Williamson, G.	CSA	✓	✓	✓	✓
Turris, B.	CGRCS and CSA	✓	✓	✓	✓
Technical Expert					
Gavaris, S.	DFO – Atlantic Canada	✓	✓	✓	✓

[1]CGRCS – Canadian Groundfish Research and Conservation Society
[2]PBCFA – Pacific Black Cod Fisherman's Association
[3]GTAC – Groundfish Trawl Advisory Committee
[4] SAC – Sablefish Advisory Committee
[5]CSA – Canadian Sablefish Association

Appendix 3: PSARC Groundfish Working Papers and Reviewers for November, 2000

2000 Groundfish Working Papers

No.	Title	Authors
G00-01	Lingcod stock assessment and recommended yield options for 2001	J. King M. Surry
G00-02	Sablefish stock assessment for 2000 and recommended yield options for 2001	V. Haist R. Hilborn
G00-03	Silvergrey rockfish (*Sebastes brevispinis*) assessment for 2000 and recommended yield options for 2001/2002	R. D. Stanley A. R. Kronlund
G00-04	Stock assessment of rock sole and English sole in Hecate Strait for 2000/2001	J. Fargo A.R. Kronlund J.T. Schnute R. Haigh
G00-05	Estimating stock biomass from tow-by-tow data for Pacific groundfish	J. Schnute R. Haigh
G00-06	Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis*) for 2000	P. Starr R. Haigh
G00-07	Design of a bottom trawl survey for three slope groundfish species in Canadian waters	P. Starr C. Schwarz
G00-08	Assessment of Pacific cod in Hecate Strait, Nov. 2000	A.F. Sinclair

List of Reviewers

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

Name	Association
Cadrin, C.	NOAA, Woods Hole, MA
Fargo, J.	DFO, Stock Assessment Division
Gavaris, S.	DFO, Maritimes Region
King, J.	DFO, Stock Assessment Division
Kronlund. A.R.	DFO, Stock Assessment Division
Ralston, S.	NOAA, Santa Cruz, CA
Saunders, M.	DFO, Stock Assessment Division
Schnute, J.	DFO, Stock Assessment Division
Schwarz. C.	Simon Fraser University
Schweigert, J.	DFO, Stock Assessment Division
Sinclair, A.	DFO, Stock Assessment Division
Smith, S.	DFO, Maritimes Region
Stanley, R.	DFO, Stock Assessment Division
Starr, P.	Canadian Groundfish Research and Conservation Society

Appendix 4: Summary of recommended yield options for 1996 to 1999 and their sources. Update for lingcod

Area	Species	1996 Yield options	1997 yield options	1998 yield options	1999 yield options	source
4B	Lingcod	Zero yield (no options proposed)	Zero yield (no options proposed)	Zero yield (no options proposed)	Zero yield (no options proposed)	Richards and Hand 1991 (Original yield) Beamish et al. 1995 (No change)
3C	Lingcod	Low risk 1400t High risk 2800 t	Low risk 1400t High risk 2800 t	≤ 1000 t	≤ 1000 t	Leaman and McFarlane 1997 (1998 yield options)
3D	Lingcod	Low risk 400 t High risk 800 t	Low risk 400 t High risk 800 t	Low risk 400 t High risk 800 t	Low risk 400 t High risk 800 t	Richards and Yamanaka 1992 (Original yield) McFarlane and Leaman 1993-1996, (no change, low risk) Leaman and McFarlane 1997 (No change)
5A/B	Lingcod	Low risk 1100 t High risk 2200 t	Low risk 1100 t High risk 2200 t	Low risk 1100 t High risk 2200 t	Low risk 1100 t High risk 2200 t	Richards and Yamanaka 1992 (Original) McFarlane and Leaman 1993-1996, (no change, low risk) Leaman and McFarlane 1997 (No change)
5C/D/E	Lingcod	1000 t (5C/D only; 5E no yield options	1000 t (5C/D/E)	1000 t (5C/D/E)	1000 t (5C/D/E)	McFarlane and Leaman 1995 (1996 yield options) McFarlane and Leaman 1996 (1997 yield options) Leaman and McFarlane 1997 (No change)

References

Beamish, R.J., B.L. Thomson and C.M. Neville. 1995. Inshore Lingcod. Pp. 25-40. *In* Groundfish Stock Assessments for the West Coast of Canada in 1994 and Recommended Yield Options for 1995. M. Stocker and J. Fargo [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 2069: 440 p.

Leaman, B.M. and G.A. McFarlane. 1997. Offshore Lingcod Stock Assessment and Recommended Yield Options for 1998. Can. St. Assess. Sec. Res. Doc. 97/131.

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McFarlane, G.A. and B.M. Leaman. 1996. Offshore Lingcod Stock Assessment for 1996 and Recommended Yield Options for 1997. Fisheries and Oceans Canada, Pacific Stock Assessment Review Committee Working Paper G96-02.

Richards, L.J. and C.M. Hand. 1991. Lingcod. pp. 19-42. *In* Groundfish Stock Assessments for the West Coast of Canada in 1990 and Recommended Yield Options for 1991. J. Fargo and B.M. Leaman [eds.]. Can. Tech. Rep. Fish. Aquat. Sci. 1778: 320 p.

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